Faculty of Resource Science and Technology

Vulnerability of Coastal Areas in South of Miri

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I, Zarina bt Hafitz Mazni, declare that the final year project report entitled:

Vulnerability of Coastal Area in South of Miri

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Signed:

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Vulnerability of Coastal Areas in South of Miri

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ABSTRACT

Miri coastal region is very climate sensitive just like any other coastal areas. It is likely to be influenced by climate changes that include sea level rise and monsoon current. It gives bad impact to the coastal areas such as beach erosion, flooding and habitat loss. Hence, this study was conducted to assess the vulnerability of the coast in South Miri using Coastal Integrity Vulnerable Assessment Toolkits (CIVAT) indicator. It focuses on the changes in geomorphological at the beach along South coast of Miri. The geomorphological changes of the beach profiles and shapes were determined by using these two main methods; Beach profiling method adapted from Emery (1961) and Shoreline tracing method adapted from Morton *et al.* (1993). The sampling was conducted at 3 selected beaches and each beach has 3 replicates. At the end of this study, the levels of vulnerability for the three beaches in South of Miri were determined.

Keywords: Erosion, vulnerability, Coastal Integrity Vulnerable Assessment Toolkits, beach profiling, shoreline tracing.

ABSTRAK

Kawasan pantai Miri adalah sangat sensitif pada iklim sama seperti kawasan pantai-pantai yang lain. Ia mudah dipengaruhi oleh perubahan iklim yang terdiri daripada kenaikan paras air laut dan arus semasa musim tengkujuh. Ia memberi kesan buruk kepada kawasan pantai seperti hakisan pantai, banjir, dan kehilangan habitat. Justeru itu, kajian ini telah dijalankan bagi menilai kelemahan kawasan pantai Selatan Miri menggunakan petunjuk Coastal Integrity Vulnerable Assessment Toolkits (CIVAT). *Ia fokus kepada perubahan geomorfologi sepanjang kawasan pantai di Selatan Miri. Perubahan geomorfologi dari segi profil dan bentuk pantai ditentukan menggunakan dua kaedah utama iaitu;* Beach profiling *yang diadaptasi dari* Emery (1961) *dan* Shoreline tracing *yang diadaptasi dari* Morton *et al.* (1993). *Persampelan telah dijalankan di 3 lokasi pantai yang terpilih dan setiap pantai mempunyai 3 replika. Di pengakhiran kajian ini, kelemahan di ketiga-tiga pantai di Selatan Miri telah dinilai.*

Kata kunci: Hakisan, kelemahan, Coastal Integrity Vulnerable Assessment Toolkits, beach profiling, shoreline tracing

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List of Abbreviation

AC	Adaptive Capacity
CIVAT	Coastal Integrity Vulnerability Assessment Toolkit
DID	Department of Irrigation and Drainage
GPS	Global Positioning System
ICSEA CCHANGE	Integrated Coastal Sensitivity, Exposure, and Adaptive Capacity to Climate Change
IPCC	Intergovernmental Panel on Climate Change
NE Monsoon	Northeast Monsoon
SW Monsoon	Southwest Monsoon
TURF	Tool for Understanding Resilience Fisheries
UNEP	United Nation Environment Programme
VA	Vulnerability Assessment

1.0 INTRODUCTION

Malaysia have approximately 4809 km long of coastline, where it is consist of 1972 km in Peninsular Malaysia, 1035 km in Sarawak and 1802 km in Sabah and Labuan (Bird, 2010). In the South of Miri, there are a few beaches such as Luak Esplanade beach and Tanjung Lobang beach. There are a few hotels and resorts located in that area. This shows that the coast of South Miri plays an important role in tourism and recreational. Whereas in the North of Miri, Kuala Baram and Lutong beach are important as a place for industrial activities such as fisheries, oil and gas production, and agriculture. Lutong beach is important as a shrimping site. Due to this, the act of monitoring and protecting the coast from pollution and erosion is important because it affects the human socio-economic activities directly or indirectly. The vulnerability of coastal systems to sea-level rise and to other drivers of change is determined by their sensitivity, exposure and adaptive capacity (Nicholls and Klein, 2005). According to Gornitz (2000), climate change has led the rise in the earth's average surface temperature from the shifts in the mean state of the climate or in its variability. Human and ecological systems and socio-economic development activities will all be affected by climate change. Due to natural and anthropogenic factors, the environment of coastal is always changing. The human induced climate change tends to aggravate the coastal area by reducing the coastal resources in that area.

Based on National Coastal Erosion Study from November 1984 to January 1986, the study results specified that out of the country's coastline of 4809 km, about 29% (1380 km) was facing erosion (Department of Irrigation and Drainage (DID), 2012). There are very few coastal studies done in Malaysia. However, there are two studies found done in Sarawak. One was in Sematan (Ezaimah Idris, 2012) and the other one was conducted in Miri (Tang and Lee, 2010).

Sarawak faces two monsoonal changes. The first monsoonal change is the northeast (NE) monsoon. It occurs between November to March. While the southwest (SW) monsoon occurs between May or early June and ends in September. Miri coastal area is exposed to South China Sea and it is easily exposed to erosion. The factors that may cause erosion to happen in Sarawak are waves, monsoon currents, tidal change, climate change and sea level rise. It is very important to always monitor and predict the level of vulnerability along coastal area, particularly at the coast of South of Miri, which not many studies have been done in that area.

Therefore, objectives of this study are:

1. To determine the geomorphological changes at the beach along South coast of Miri
2. To obtain the vulnerability level of the coasts in South Miri

2.0 LITERATURE REVIEW

2.1 Coastal of Miri

Miri, the birthplace of Malaysia's petroleum industry, is located on the northern region of Sarawak, in East Malaysia. It is the second largest city in Sarawak. It is situated at the latitude of 04° 23' 0''N and longitude of 113° 59'0''E. The length of the coastline is approximately 32 km. In the South part of the coast of Miri, there are a majority of coral reefs sites mainly at the coast of Bakam. Kenyalang Reef, Scubasa's Reef, and Tyre Reef are among the major reef sites in the coastal zone of South of Miri. Along Luak Esplanade beach to Tanjung Lobang beach, there are also a few hotels, resorts and condominiums located in that area. This proves that the coast of South Miri helps in improving our tourism industry. However, in the North part of coast of Miri, there are many places for industrial activities such as fisheries, oil and gas production, and agriculture.

2.2 Coastal Terminology

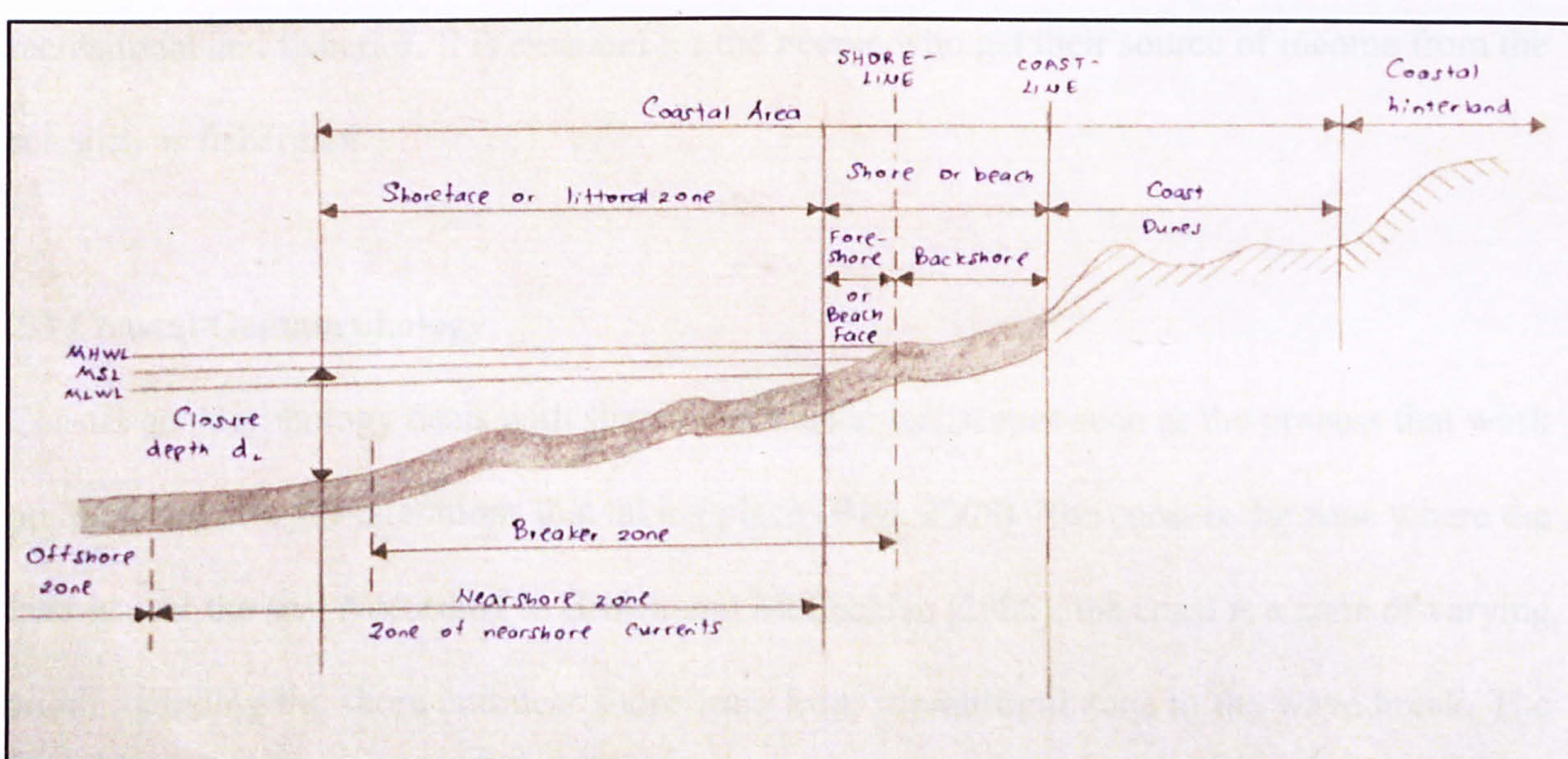

Figure 1: The terminology of coastal zone

According to Sharifah Mastura (1992), coastal zone refers the zone as a small area of land and wetland that adjacent to the shoreline. It is the line where the sea and the land combine (refer Figure 1). The nearshore zone is a zone consists of the surf zone and the swash zone. It moves back and forth as the tides rise and fall. Breaker zone is the zone where the waves approaching the coastline begin to break and the water depth in this zone is between 5 m and 10 m. The terms offshore, onshore and longshore are used to explain the directions of flow of wind, water or sediment. The term coastline is basically known as the line that separates the coast and the shore. Dunes is where the place where accumulation of windblown sand on the backshore happen.

2.2.1 Importance of Coast

The coastal zone is crucial to many marine lives. The wetlands, lagoons, sea grass beds, coral reefs and shallow bays are used as feeding and nursery ground for many oceanic species. The coast of Miri is also valuable for its natural resources and its aesthetic values such as tourism, recreational and fisheries. It is essential for the people who get their source of income from the sea such as fishermen.

2.3 Coastal Geomorphology

Coastal geomorphology deals with shaping of coastal landscapes such as the process that work on them and also the alterations that taking place (Bird, 2008). The coast is the zone where the land is near the sea. According to Brown and McLachlan (2006), the coast is a zone of varying width including the shore and near shore zone from supralittoral zone to the wave break. The coastal areas are important to many people especially for those who live and work in that area.

It is also important as a place for recreation activities. Coastal geomorphology deals with the shaping of coastal features, the process that occur on that beach, and the changes that happen on that beach.

2.3.1 Beach

According to Bird (2008), a buildup on the shore of generally loose, unconsolidated sediment, size ranging from very fine sand up to pebbles, cobbles and sometimes boulders which often with shelly material are defined as beach. Gaining or losing of sediment are experience by most of the beaches. Most beaches are exposed to the open ocean or stormy seas. Whereas, some are sheltered in bays or behind the islands or reefs.

2.3.2 Beach Sediment

There is a range of various sediment sizes (refer Figure 2). It is normally consisting of sediment as big as boulder (larger than 256 mm) up to clay (smaller than 0.0039 mm). Some of their differences are crucial to understanding coastal erosion processes. It is also important to describe the beach. Different sizes of sediments, or rocks, have different resistances to erosion; that is, they are more likely or less likely to erode. Usually, smaller sand sizes have flatter beaches. Coasts which are formed in tightly packed materials such as glacial till and bedrock, are less likely to have erosion and do not experience much recession. However, coast that are formed from loosely packed sediments are more prone to face erosion and more recession.

Figure 2: Sediment size particle guide

2.4 Coastal Erosion and Accretion

A natural process that involves the disintegration (or "weathering") of rock and sediments at the shoreline, above and below water surface is known as coastal erosion (Lech and Trewin, 2013). The migrations of landward movement of the shoreline as cliffs recede or as beach and dune systems are the results from coastal erosion. In certain places, dunes and salt marshes may vanish completely, however, in some other places new depositional features such as beaches and spits might form. The beach becomes narrower and lower in elevation due to the loss of sand. Beach profiling is a rapid method used to measure the variations in the gradient slopes of the monitored beach and how it changes from time to time. It is also used to study the beach seasonal recovery. According to Brander (2007), knowing the gradient of the beach slope is crucial because steeper gradient indicates that the beaches are having erosion. According to National Coastal Erosion Study 1986, Malaysia's shorelines are categorized into 3 categories of erosion depending on the threats that it caused to the shore-based facilities in that area. Those 3 categories are:

Category 1: Currently, the shorelines and shore-based facilities are in great danger of collapse or damage due to the erosion.

Category 2: If no actions are taken within 5 – 10 years, the shoreline will shows greater erosion while the public property, infrastructure and agriculture land will become threatened.

Category 3: If undeveloped shoreline is left unchecked, it will only cause minor economic loss even though the shoreline are experiencing erosion.

Coastal accretion is the opposite of coastal erosion. It causes the beach to become wider. Accretion starts when there is sand accumulation on shore due to the movement of the waves, tides and longshore current. Waves, generated by storms, wind, or tides, can lead to erosion as well as coastal accretion. New deposition of san mainly comes from inland deposition or from sediment transport from the adjacent river systems.

2.4.1 Impacts of Coastal Erosion

2.4.1.1 Habitat Loss

Coastal erosion can destroy the coastal natural resource systems in that area. Examples of coastal natural resources are wetlands, lagoons, sea grass beds, coral reefs and shallow bays These natural resources are essential to the marine life as it provides them with food and nursery ground. Besides that, it also provides them shelter. Without these natural resources, their habitat will be lost.

2.4.1.2 Loss of Beaches

The erosion rates are increasing through much of the world and this has caused loss of beaches. It can give risk to property and loss of international tourism revenue. If the coastal erosion happens continuously, it can change the geomorphological pattern in the coastal area. The changes of the coast can be measured by using beach profiling method and shoreline tracing method.

2.5 Coastal Processes

Coastal processes are unpredictable and the levels of activity are high. Due to this, the condition of the coastal area often rapidly changes occasionally. Examples of processes that can affect the coast are waves, monsoon current, and tides.

2.5.1 Waves

Waves are created when the wind blows on the ocean surface of water. it cause erosion by dragging the sand from the beach and pulling the sand back into the sea. This usually happens during storms and other major weather events. The stronger the waves, the more obvious the changes of geomorphological pattern along the coastal area.

2.5.2 Monsoon Current

Miri has an equatorial monsoon climate due to its location in the equator. The temperature is consistently high throughout the year. There are two seasons involve in this type of climate. The first one is dry season and the second one is wet season. According to Sharifah Mastura (1992), the changes in the course and speed of the monsoon winds are led to the separation of the year into four seasons. The four seasons are northeast (NE) monsoon, southwest monsoon (SW) and the two transitional periods. The wind also disturbs the water in the shallow coastal area and caused erosion.

2.5.3 Tides

The gravitational effects of the moon and the sun in relation to the earth are the main factors that create the movement of tides in the ocean. They flow across the oceans and into bays, inlets and lagoons as very long waves. Tidal forces can influence minor fluctuations in land levels and wave actions. As a whole, tidal currents carry sediment along the coast in the nearshore zone, and this eventually be delivered to beaches alongshore.

2.6 Previous Studies

Previous studies that are related to coastal erosion in Malaysia are done by National Coastal Erosion Study 1986.

Table 1: Distribution of eroded coastal area in Malaysia (adapted from DID, 2012)

Area	Distance	Eroded coastal categories			Total distance of eroded coastal in 1985	
		Category 1	Category 2	Category 3		
	Km	Km	Km	Km	Km	%
Peninsular	1972	255.8 (78)	164.5 (43)	618.9 (52)	995 (156)	73
Sarawak	1035	17.3 (8)	22.3 (10)	9.6 (7)	45 (21)	3
Sabah & Labuan	1802	15.3 (7)	6.5 (4)	304.3 (14)	326 (24)	24
Total	4809	288.4 (93)	193.3 (57)	932.8 (73)	1366 (201)	100

( ) Number of sites

Table 2: Length and number of sites affected by erosion in each category between year 1986 to 2000 (adapted from DID, 2012)

Category	No. of sites / Length	1986	2000
Category I	No. of sites	47	74
	Length (km)	156	233
Category II	No. of sites	75	64
	Length (km)	243	221
Category III	No. of sites	76	77
	Length (km)	973	946
Total	Length (km)	**198**	**215**
		1372	**1400**

The National Coastal Erosion Study (1985) said that coastal erosion affects every state in Malaysia. This problem has been supported by reports of the Malaysian government (Department of Irrigation and Drainage (DID), 2012). However, the available data for the study sites in South of Miri is limited. According to Table 1, between 4809 km of shoreline in Malaysia, about 288.4 km of shoreline in Malaysia were classified as Category 1 of erosion in year 1985. This shows that the coastal erosion was seriously critical and it threatens the facilities there. Peninsular Malaysia had the highest percentage of total distance of eroded coastal which was 73% (995 km). Sabah and Labuan had the second highest percentage of total distance of eroded which was 24% (326 km), and that leaves Sarawak in the third place with 3% (45 km). Miri's shores are receiving uninterrupted and strong waves from the South China Sea because in that coastal water area, there are a few numbers of little islands and reef barriers (Tang and Lee, 2010). Based on Table 2, the total distance of eroded coastal in

Malaysia in year 1985 had increased from 1366 km to 1400 km in year 2000. This proves that the erosion rate in our coastal water has increased and it is critically affected in some areas. If no action is taken, more beaches will be eroded.

2.7 Coastal Vulnerability

The IPCC defined the vulnerability term in their Fourth Assessment Report (2007) as followed:

> *"Vulnerability to climate change is defined as the degree to which geophysical, biological and socio-economic systems are prone to, and unable to cope with, adverse impacts of climate change".*

(Intergovernmental Panel on Climate Change (IPCC), 2007)

Besides that, vulnerability is also defined as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (McCarthy *et al.,* 2001). The vulnerability of coastal systems to sea-level rise and to other drivers of change is determined by their sensitivity, exposure and adaptive capacity (Nicholls and Klein, 2005). Refer Table 2 for description of vulnerability indicators. Sensitivity and Exposure may be taken together to yield Potential Impact (Allison *et al.,* 2009).

Table 3: Description of vulnerability indicators (adapted from Allison *et al.,* 2009)

Vulnerability indicators	Description
Exposure	Quantify the Intensity or severity of physical environment Conditions driving changes in the present state of biophysical systems.

Sensitivity	Describes the present state of the system, regarding specific properties that respond to exposure factors arising from climate change.
Adaptive Capacity	The ability of the system to tolerate with impacts associated with changes in climate.

In Figure 3, the relationship between those three components is shown. The vulnerability of the areas will be analyzed based on 3 criteria. The 3 criteria are sensitivity, exposure and adaptive capacity. In this research, the vulnerability will be computed using cross-tabulation approach based on formula in Figure 4.

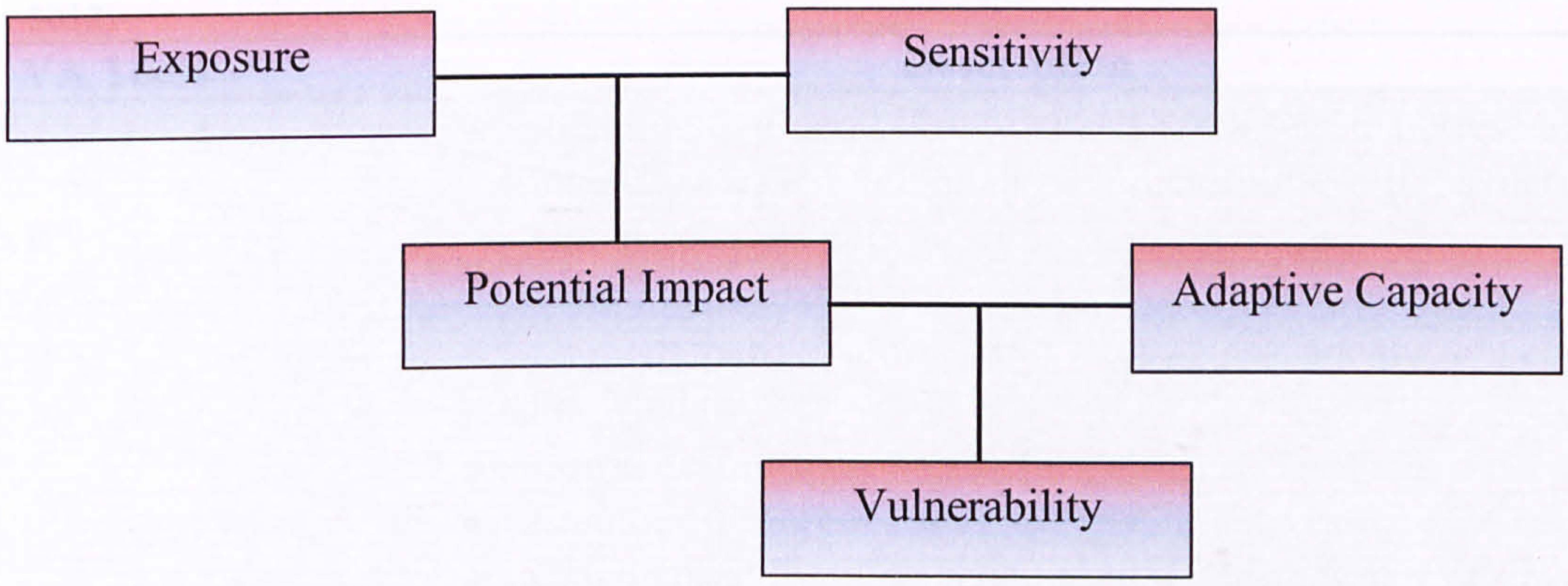

Figure 3: Relationship between Exposure, Sensitivity and Adaptive Capacity (adapted from Aliño *et al.*, 2013)

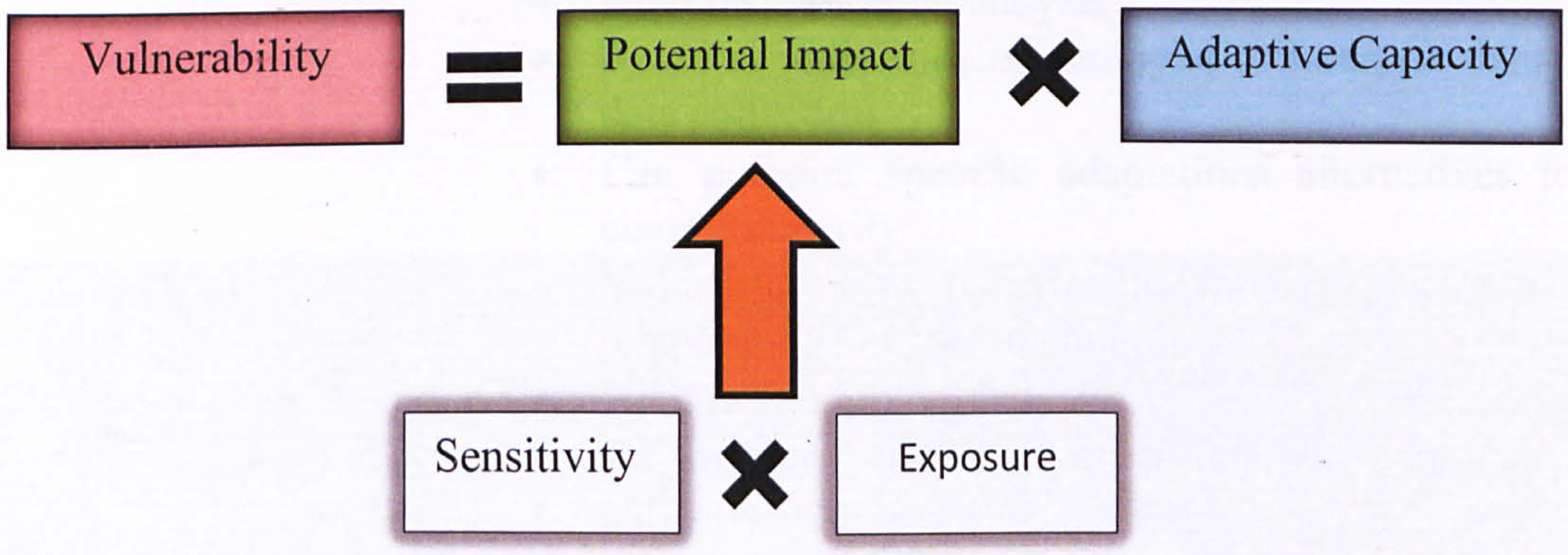

Figure 4: Formula for obtaining the vulnerability

2.8 Vulnerability Assessment (VA) Tools

There are three criteria needed when we want to measure the vulnerability. The three criteria are exposure, sensitivity and adaptive capacity. To judge the alteration of vulnerability by external stressors like the adverse effects of climate change, the observations has to be progressive and long term, since events can be continuous and discrete, showing the various facets of this global and dynamic process (Romieu *et al.*, 2010). There are many types of coastal vulnerability assessment tools that can be used in measuring the coastal vulnerability.

Table 4: A table showing available tools for assessing vulnerability at coastal area (adapted from MERF, 2013)

VA Tools	Description
ICSEA CChange	• Integrated vulnerability of coastal area (eg: fisheries, coastal integrity and biodiversity vulnerabilities to synergistic climate change exposure) • Scoping and surveying • Highly participatory and engaging local stakeholder knowledge • Lower resolution of analysis • Cannot offer precise adaptation alternatives • Can be used to relate general vulnerabilities across sites • Assesses available data and information for use in CIVAT and TURF
CIVAT	• Vulnerability of coastal integrity to sea level rise and waves exposure • High resolution of analysis • Requires assistance of geologist to interpret data and guide data collection • Can pinpoint specific adaptations alternatives to develop coastal integrity
TURF	• Vulnerability of fisheries to wave exposure, sea surface temperature, and sedimentation • High resolution of analysis • Depend on fisheries expert to interpret data and guide data collection • Can find specific adaptation alternatives to lessen fisheries vulnerability to climate change